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Are Neural Responses of University Students on the Broader Autism Phenotype Affected by Pain in Racial Ingroup and Outgroup Members?

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Running Head: NEURAL RESPONSE TO PAIN

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Abstract

The current research aimed to examine whether the neural expression of empathy in response to the pain of racial ingroup and outgroup members might differ as a function of individuals' autistic traits. In the current study, 40 neurotypical undergraduates completed a task in which they viewed a series of pictures of black and white hands in painful and non-painful situations while EEG was recorded to measure mu suppression, a neural measure of empathic processing. Participants also completed questionnaires that measured autistic traits, racial prejudice, and familiarity with racial outgroup members. Although there was a marginally significant interaction between autistic traits and race, simple main effects analyses revealed that there were not significant differences in how individuals high and low in autistic traits processed the different races. Autistic traits were not related to levels of mu suppression. Additionally, the condition of the stimulus (pain versus non-pain) was not related to levels of mu suppression. The current study did not support our hypotheses and in fact yielded null effects. Limitations of the study design and sample are discussed and suggestions for future research are given.

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Autism and Empathy

Navigating everyday social situations is crucial for human survival and necessitates a range of social cognitive processes in which individuals must monitor social context and meanings along with others' behaviors (Fiske & Haslam, 1996). The human ability to interpret actions and gestures of others is imperative to social interactions (Chong et al., 2008). Individuals with autism spectrum disorder (ASD) exhibit impairments in many social cognition processes, which can lead to impaired social interactions (American Psychiatric Association [APA], 2013). In particular, persons with ASD experience deficits in empathy compared with individuals not on the autism spectrum (Lombardo et al., 2007).

Empathy is the ability to share and understand others' intentions and feelings (Preston & de Waal, 2002; Decety & Jackson, 2004; Gallese, 2006). Empathy is an important component of social interactions (Kennett, 2002) as it provides insight into others feelings and intentions (Decety & Jackson, 2004) and allows for socially appropriate responses (Hickok, 2009). Studies have shown imitation and mimicry facilitate empathy (Iacoboni, 2009; Kaplan et al., 2006). Because observations of actions are necessary for empathic feeling (Carr et al., 2003), empathy is often studied within the context of mirror neurons.

Mirror neurons are a class of neurons that respond both when a specific action is performed and when the same action, performed by a different individual, is observed

(Gallese & Goldman, 1998). Activation of the mirror neuron system is commonly measured over the sensorimotor cortex in humans using EEG (Pineda, 2005). This activation of the mirror neuron system is thought to be indexed by suppression of oscillatory activity in the frequency range 8-13 Hz and is called the mu rhythm (Cheng et al., 2008). Previous studies have shown that participants viewing individuals reaching towards objects show a suppression of the mu rhythm (Muthukumaraswamy et al., 2004). Additionally, participants show a suppression of the mu rhythm when viewing a video of others tossing an object towards a camera (Oberman et al., 2007). Thus, we can study the activation of the mirror neuron system by looking at levels of mu suppression.

Mirror neurons also assist individuals in detecting certain mental states of others (Gallese & Goldman, 1998). In a study where subjects viewed faces expressing emotions and had to either focus on their own emotional response to each face or evaluate the emotional expression of the face, mirror neurons were only activated when participants had to respond to the emotional state on the face; this demonstrated that mirror neurons are not only involved in motor cognition but also in emotional interpersonal cognition (Schulte-Rüther et al., 2007). Mu suppression has been used as an indicator of empathy: high levels of mu suppression signify high levels of empathy (Oberman et al., 2005). For example, previous research shows that females demonstrate more mu suppression than males while observing painful situations (Yang et al., 2009). Together, this work indicates that mu suppression can provide a physiological measure of empathy.

Individuals with ASD show significantly reduced attenuation of the mu rhythm when executing an action. For example, adults with ASD demonstrated significantly poorer performance and less mu suppression compared to neurotypical adults when asked to imitate a series of hand movements that they observed on a computer screen (Bernier et al., 2007). In another study, people with ASD showed significant mu suppression to self-performed hand movements but not to observed hand movements, supporting the hypothesis of a dysfunctional mirror neuron system in individuals with ASD (Oberman et al., 2005). These studies support the accepted notion that people with ASD show deficits in overall imitation abilities (Bacon et al., 1998; Rogers et al., 2003).

Although this research has demonstrated differences in mirror neuron activity to human movement, there is little EEG research that shows whether people with ASD express empathy when shown humans in situations that typically yield empathic responses. Thus, more research is needed investigating whether autism is associated with deficits in mu suppression when viewing others in situations that yield empathic responses in neurotypical individuals.

Empathy and Racial Group Status

Studies have shown that racism can reveal itself through a lack of empathy (Feagin & Vera, 2001; Cosmides et al., 2003). However, additional research has found that racial group membership can alter these feelings of empathy (Todd, et al., 2012; Sheng & Han, 2012; Xu et al., 2009). In other words, individuals belonging to different racial groups can attenuate or accentuate levels of empathy. For example, in a study that showed participants pictures of hands in painful

situations, white participants displayed more empathy, as measured with a combination of event-related fMRI and pupil dilation as an index of autonomic reactivity, to pictures of white hands and black participants displayed more empathy to black hands (Avenanti et al., 2010). Thus, it appears that racial group membership modulates empathic response such that empathic responses to perceived pain are stronger to racial in-group members than to racial out-group members (Sheng & Han, 2012).

Some research has also investigated the effect that race has on mu rhythm processing. In a study where participants watched videos showing a variety of racial ingroup and outgroup members performing a simple action, participants displayed more mu suppression when observing ingroups act compared to when they observed outgroups, illustrating that participants had more mu suppression when the actors were part of their ingroup than their outgroup (Gutsell & Inzlicht, 2010).

However, other research argues that mirror neurons are only active in social-perceptual tasks (identifying facial expressions based on photographs only of the eye region of the face) and not in social-cognitive tasks (making attributions of wordless cartoon images), suggesting that additional mechanisms outside the mirror neurons are needed to make mental attributions of beliefs (Pineda & Hecht, 2009). Thus, it is possible that preconceived notions about race might not impact mu suppression.

Current Study

Taken together, the findings described above suggest that individuals with ASD tend to demonstrate lower levels of empathy than non-ASD individuals and that neurotypical individuals tend to demonstrate higher levels of empathy in response to an in-group rather than an outgroup target. Research has not studied whether people with ASD present racial ingroup/outgroup bias and how that might affect their empathy towards others. More research is needed to investigate whether people with autistic-like behaviors express empathy when shown stimuli of others in pain, and how racial group membership might affect this empathic response. Being able to understand and demonstrate empathy is an important social skill, especially when witnessing other people in pain. If we are able to see that people high in autistic traits lack this ability, then we will better understand this deficit in social skills, giving us new insight into the ASD population. Furthermore, if we see that race moderates this empathic response, we will have a novel understanding of how racial group status moderates empathic response in the ASD population—a topic on which there is very little research.

The body of work examining empathic responses in autism has focused on comparing individuals with autism to those without autism. Researchers have suggested that, due to the nature of autism as a spectrum disorder, studying the Broad Autism Phenotype (BAP; Bolton et al., 1994) can lead to a stronger understanding of the mechanisms underlying ASD and can assess challenges faced by neurotypical individuals who express similar but less intense variations of autistic traits (Wainer et al., 2011). The BAP has been largely ignored in the study of empathy, despite the fact that autistic traits are distributed and heritable

in the general population (Constantino & Todd, 2003; Hoekstra et al., 2007; Stewart & Austin, 2009). Studying individuals along the BAP may be useful for gaining insight into processing differences that lay along a continuum involving diagnosed and non-diagnosed individuals.

Research is needed to examine how traits related to autism differentially affect empathic processes when it comes to expressing empathy in response to ingroup and outgroup members in pain. Although previous studies have clearly shown that people who display autistic behaviors show less empathy than those who do not display autistic behaviors, there is little research on whether painful stimuli will elicit this empathic response. Investigating how this response might differ based on race will also lead us to novel insight on the ASD population: research shows that people with ASD show deficits in social interaction, however whether racial ingroup status plays a role in these deficits is not known. Researching this will help us to better understand the social skill deficit among the ASD population since empathic processing allows for a socially appropriate response when someone is in pain. Additionally, while people with ASD tend to have attentional deficits, if we see a difference in response to black versus white stimuli, we can conclude that people with ASD cognitively attend to the differences between ingroup and outgroup stimuli. The current study investigated whether people with high levels of autistic traits (versus people with low levels of autistic traits) expressed empathy while seeing pictures of hands in pain, and how racial ingroup status affected this expression of empathy.

In the current study, we employed a task to assess empathic responses. We modeled our task from a previous study that investigated how implicit racial bias affected empathic responses to painful situations (Avenanti et al., 2010). Participants were shown a series of pictures of hands in painful (with a needle piercing the hand) and non-painful (with a cotton-tip piercing the hand) situations. The hands in the pictures were of white and black hands. EEG data was collected to determine levels of mu suppression to evaluate the levels of empathy and how racial group status might affect this empathic response.

The goal of the current work was to examine the unique contribution that autistic behaviors contribute to neural processing in this social cognitive task and how race might moderate this response. Autistic traits were measured using the Autism Spectrum Quotient (AQ), a self-report measure that quantifies an individual's level of autistic traits (Baron-Cohen et al., 2001). The AQ has been used in previous work to study the BAP (e.g., Austin, 2005).

Because people with autism tend to have lower levels of activity in their mirror neuron system (Oberman et al., 2005), we expected that individuals who scored higher on the AQ would demonstrate less mu suppression in response to the painful stimuli than those individuals who scored lower on the AQ. In addition, we expected to replicate previous work showing that ingroup members yield greater mu suppression than outgroup members in response to ingroup stimuli (Gutsell & Inzlicht, 2010). Finally, we expected that people who scored higher on the AQ would not show differences in processing based on pain and response but that those lower on the AQ would demonstrate more mu suppression

in response to pictures of ingroup compared to outgroup members in pain compared to those who scored higher on the AQ.

Method

Participants

Undergraduate students (N = 40; 23 males; M_{age} = 19.5 years; 100% White) from a medium-sized university in the southeastern United States participated for course credit in an introductory psychology class. All procedures were approved by the Protection of Human Subjects Committee.

Stimuli

Stimuli were color pictures of hands in painful and non-painful situations on a computer screen (see Appendix A for pictures showing the different types of stimuli). The hands in painful situations were depicted with a needle touching the hand. The hands in non-painful situations were depicted with a cotton tip touching the hand. Hands also varied according to race. Thus, there were four conditions: white hand with needle, white hand with cotton tip, black hand with needle, black hand with cotton tip. There were four different pictures used for each of the four conditions, totaling to sixteen different pictures. All pictures were used in a previous study exploring racial empathy (Avenanti et al., 2010).

Paradigm

Stimuli were presented one picture at a time. Each picture appeared for 6 seconds with an inter-trial interval of 6 seconds. Participants completed 25 blocks of 4 trials each, in

which their task was to simply pay attention to the stimuli presented on the screen. Participants were told that they would later be asked questions about the pictures to ensure that they would pay attention to the task. The order of the pictures was randomized. Participants were seated approximately 90 cm from the screen.

EEG

The electroencephalogram (EEG) was recorded from 28 scalp sites using tin electrodes sewn into an electrode cap (Electrocap, International, Eaton, OH), according to an extended 10–20 system (Jasper, 1958). Active scalp sites were referenced online to the right mastoid; an average mastoid reference was derived off-line. Vertical and horizontal movements of electrooculograms were recorded with electrodes placed above and below the left eye and on the outer canthus of each eye. Electrode impedances were kept below 5 KOhms at all sites. EEG was sampled at 250 Hz by Neuroscan Synamps (Compumedics USA, El Paso, TX) amplifiers and was filtered online at .01 to 40Hz. Ocular artifacts were removed using a regression-based procedure (Semlitsch et al., 1986). Trials containing voltage deflections of 75 microvolts (mV) were removed prior to averaging according to participant, electrode and stimulus conditions. Averages were further lowpass filtered offline at 12 Hz.

Materials

Familiarity With Outgroups. The Familiarity With Outgroups questionnaire is a 13-item self-report measure of personal interactions with black people (Walker et al., 2008; $\alpha = .79$). Participants were asked to respond to questions like "I often talk to Black people in college" using a 5-point scale, (1 = *strongly disagree*, 2 =

sort of disagree, 3 = *not sure*, 4= *sort of agree*, 5=*strongly agree*). Scoring was used with higher scores indicating more familiarity with outgroups.

Autism Quotient. The Autism Quotient questionnaire (AQ) is a 50-item self-report measure of autism-spectrum behaviors (Baron-Cohen et al., 2001b; α = .73). Participants respond to a series of statements like "I like to plan activities I participate in carefully" using a 4-point scale, (1 = *definitely agree*, 2 = *slightly agree*, 3 = *definitely disagree*, 4= *slightly disagree*). Dichotomous scoring was used with higher scores indicating more autistic behaviors.

Attitude Towards Black. This is a 20-item self-report measure of explicit attitudes towards black people (Brigham, 1993; α = .88). Participants respond to a series of statements like "I would probably feel somewhat self-conscious dancing with a Black person in a public place" using a 7-point scale, (1 = *strongly disagree*, 2 = *disagree*, 3 = *disagree somewhat*, 4= *neither agree nor disagree*, 5= *agree somewhat*, 6=*agree*, 7=*strongly agree*). Higher scores indicate a stronger racial bias against blacks.

Procedure

This was a two-part research study. In part one, participants completed a computer task in the EEG lab. After completing an informed consent form, participants were taken into the EEG lab and hooked up to the electrode cap. All protocols involving safe and sanitary concerns were taken during the experiment to ensure participant and experimenter safety. After the preparation of the EEG cap was finished, participants viewed a series of pictures of hands in painful and in non-painful situations on a computer screen. The

display of stimuli lasted between 30-35 minutes. In part two of the study, which occurred within 7 days of completion of part one of the study, participants completed a series of questionnaires in a university computer lab.

Results

Participant Characteristics

Of the 40 undergraduate students who were recruited, five were excluded because of missing data and eight were excluded because of excessive artifacts in their EEG data. Thus a total of 27 participants' data were analyzed (15 males, M_{age} = 19.1 years; 100% White). Based on their self-report measures, participants were divided into two groups using a median split: high AQ individuals that expressed autistic behaviors (n = 11, M_{AQ} = 12.4, SD = 3.3), or low AQ individuals that expressed neurotypical behaviors (n = 16, M_{AQ} = 21.8, SD = 4.0). These means were significantly different from one another, $t(38) = -8.44$, $p < .001$

Mu Rhythm

A time-frequency analysis was performed using EMSE software to characterize mu suppression over the 6-s interval following target presentation. Event-related spectral perturbation (ERSP) was computed in EEGLAB using Morlet wavelets over segments of data spanning -7,000 to 8,000 ms relative to stimulus onset from electrodes C3 and C4 for each trial. These electrodes were selected because they have been demonstrated to be the most robust locations for measurement of the mu rhythm in topographical studies (McFarland et al., 2000) and because they are the most commonly used locations for measurement of the mu rhythm in studies of children (Marshall & Meltzoff, 2011), the

development of brain-computer interfaces (Pineda et al., 2003), and in studies of social cognition (Pineda & Hecht, 2008). A 5-s interval between -6,000 ms and -1,000 ms with respect to target image onset was used for baseline normalization. The wavelet analysis was performed over frequencies between 2 and 75Hz. Mu desynchronization was quantified as the average ERSP (dB-scaled) over the mu (8–13 Hz) frequency range, averaged over the -5,000–6,000 ms poststimulus epoch and electrodes C3 and C4.

Analytic Strategy

To examine the effects of image content and type of stimulus on the mirror neuron systems in people that demonstrated low and high levels of autistic behaviors, this measure of mu suppression was submitted to a 2 (Race: black or white) x 2 (Condition: touch or pain) x 2 (AQ: low or high) analysis of covariance with ATB ($M = 2.11$, $SD = .84$) and FWO ($M = 3.48$, $SD = .83$) as covariates. We used these two self-report measures as covariates in order to control for prejudice. Research has shown that the processing of race is associated with prejudice and with FWO (Dickter et al., 2015). The mu suppression data were transformed by multiplying by 100,000.

There was no main effect of race, $F(1,22) = 0.65$, $p = .43$, $\eta_p^2 = .029$, nor was there a main effect of condition, $F(1,22) = 1.25$, $p = .28$, $\eta_p^2 = .054$. The main effect of AQ was also not significant, $F(1,22) = 0.77$, $p = .39$, $\eta_p^2 = .034$. Results revealed that there was a marginally significant interaction between AQ and race, $F(1,22) = 3.15$, $p = .09$, $\eta_p^2 = .13$, as demonstrated in Figure 1. In order to break down this interaction, simple main effects analyses were conducted for each group. For the high AQ group, there was less mu suppression for black hands ($M = 315.78$, $SE = 61.46$) than for white hands ($M = 315.80$, $SE = 61.47$), $t(18) = -.002$, $p = .99$, $d = 0.00$, although this was not significant.

For the low AQ group, there was less mu suppression for black hands ($M = 221.14$, $SE = 39.66$) than for white hands ($M = 225.71$, $SE = 41.71$), $t(19) = -1.31$, $p = .205$, $d = 0.11$, but this was also not significant. There was also no significant interaction between AQ and condition, $F(1,22) = 2.35$, $p = .139$, $\eta_p^2 = .097$.

Discussion

The current research investigated whether individuals differing in the amount of autistic traits differed in their empathic response to seeing others in pain and whether race might moderate this empathic response. We examined neurotypical individuals representing the BAP which allowed us to investigate mechanisms that may underlie ASD and assess challenges faced by individuals with high numbers of autistic traits. Participants viewed a series of pictures of black and white hands in painful and non-painful situations while EEG was recorded to measure mu suppression, an index of empathy. Although there was a marginally significant interaction between autistic traits and race, simple main effects analyses revealed that there were not significant differences in how individuals high and low in autistic traits processed the different races. In addition, contrary to what was expected, autistic traits were not related to levels of mu suppression. Additionally, the condition of the stimulus (pain versus non-pain) was not related to levels of mu suppression. Thus, our hypotheses are not supported by the current study.

In the current study, there was a marginally significant interaction between race and AQ. Examination of this interaction demonstrated that the effect of race was not significant for either AQ group, although there was a trend for the black hands to yield less suppression than the white hands. This finding is consistent with previous work

showing that racial group affects levels of mu suppression (Gutsell & Inzlicht, 2010; Avenanti et al., 2010). We are hesitant to conclude that racial group status affects levels of mu suppression based on autistic traits; future research should investigate this relationship further.

In the current study, autistic traits were not related to levels of mu suppression. In other words, there was no significant difference in mu suppression between participants high in autistic traits and those low in autistic traits. Previous research has shown that people with ASD demonstrate lower levels of mu suppression (e.g., Bernier et al., 2007; Oberman et al., 2005) compared to a matched neurotypical sample. It is possible that our sample did not demonstrate a high enough level of autistic traits to distinguish a difference in levels of mu suppression between participants high in autistic traits and participants low in autistic traits and to replicate previous studies that used samples of clinically autistic individuals. However, we chose to study individuals along the BAP because the BAP has been largely ignored in the study of empathy. Additionally, researchers have suggested that studying the BAP can lead to a stronger understanding of the mechanisms underlying ASD and can assess challenges faced by neurotypical individuals who express similar but less intense variations of autistic traits (Wainer et al., 2011). Studying individuals along the BAP may be useful for gaining insight into processing differences that lay along a continuum involving diagnosed and non-diagnosed individuals.

Additionally, the condition of the stimulus was not related to levels of mu suppression in the current study. In other words, there was not a significant difference in levels of mu suppression in response to hands in pain (being struck with a needle) versus

hands in non-pain (being touched with a q-tip), nor was this moderated by AQ. While previous studies have shown that people with autism demonstrate lower levels of mu suppression in response to different types of stimuli (Oberman et al., 2005), this difference in mu suppression is often found when individuals are asked to imitate or execute an action (Bacon et al., 1998; Rogers et al., 2003). However, there is little research that investigates the difference in levels of mu suppression in response to painful situations. It is possible that there is not a difference of mu suppression expressed between autistic and non-autistic individuals when presented with painful stimuli.

There are several limitations of this work that should inform future research. One limitation is our focus on college students as participants. We chose this sample because the university setting has been shown to be challenging for individuals with ASD (Koegel et al., 2013; Wei et al., 2013). While all of the students in the current study represented the BAP, they are also high-functioning and successful in college, thus they may not display enough autistic traits in general or their traits may not impair their processing as much as non-college students.

Another limitation of our study is the use of static stimuli to assess empathic response. We used static stimuli because previous research has elicited mu suppression in response to static images (Dickter et al., 2013). However, more research has used dynamic goal-directed actions to elicit mu suppression (Muthukumaraswamy et al., 2004; Warreyn et al., 2013; Oberman et al., 2005). Thus, these findings may not generalize to everyday situations since empathy is often conveyed in response to situations with dynamic movements. Future research should use dynamic hands to assess empathic processing in these groups. Lastly, we could have recruited a similar matched sample of

all black participants to compare their racial in-group bias with that of the white participants. We would expect that the black participants would demonstrate greater mu suppression for the pictures of black hands while the white participants would demonstrate greater mu suppression for the pictures of white hands. Future research should compare these differences.

Additionally, our findings might have been limited since we used a median split for AQ when calculating the results. Median splits are frequently used in order to distinguish between high and low levels of a specific trait in a small sample size (Dahlen et al., 2004; Ruiz et al., 2006; Van Dongen et al., 2011). However, it is possible that the use of this variable in our calculations might have led to less significant results. Median splits of continuous variables reduce power of statistical tests, making it much more difficult to identify significant effects, even when they do exist (Cohen, 1983).

In the future, we plan to analyze event related potentials (ERP) in the current data set using the EEG data that will give us a new perspective of participants' neural processing during the task. An abundance of previous research has concluded that ERPs are useful in investigating the impairments in executive function and processing in autism (e,g,, Jeste & Nelson, 2009; Webb et al., 2006; Senju et al., 2005) and in examining the cognitive processing of race (Dickter & Bartholow, 2007; Stahl et al., 2008; Sheng et al. 2013). We will be able to use ERPs to investigate potential differences in cognitive processing between individuals high in autistic traits and those low in autistic traits in response to painful and non-painful stimuli.

Understanding the unique contributions of autistic traits in different tasks that necessitate a specific skill set can help inform training or interventions for BAP

individuals and can also contribute to our understanding of ASD. Future studies should continue to research the difference in expression of empathy in response to observation of painful situations between people low and high in autistic traits, specifically looking at how race modifies this relationship. However, using a larger and clinically diagnosed autistic sample with a matched control sample might lead to more significant results. Empathy is an important social skill, especially in response to seeing others in pain, and if we can understand why people high in autistic traits demonstrate less empathy, especially if it is correlated with a racial group status, we will be able to better understand the ASD population as a whole.

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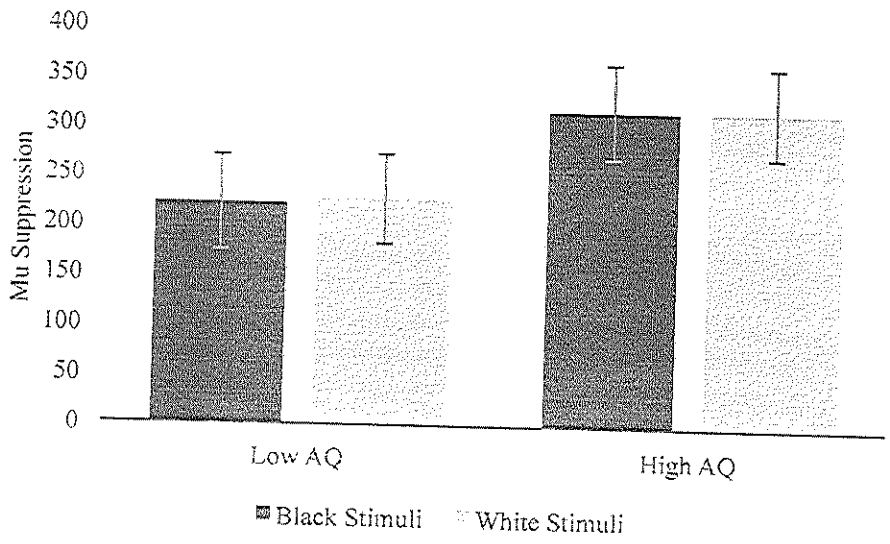

Figure 1. Mu suppression as a function of race and AQ

APPENDIX A

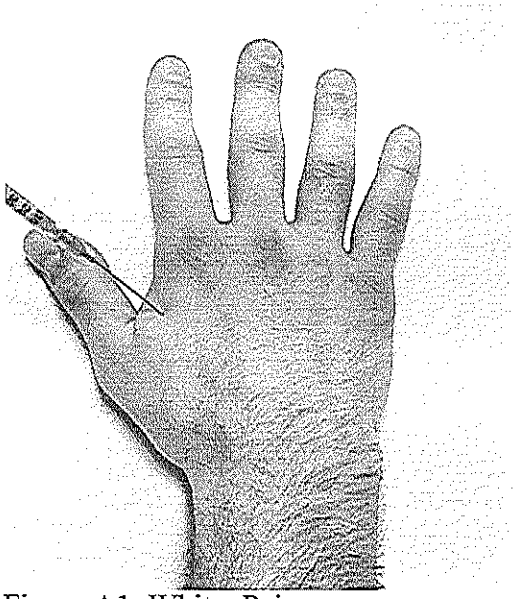

Figure A1. White, Pain

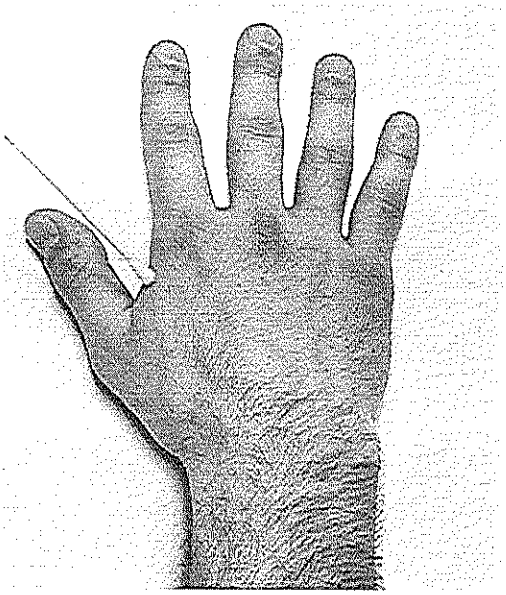

Figure A2. White, Non-Pain

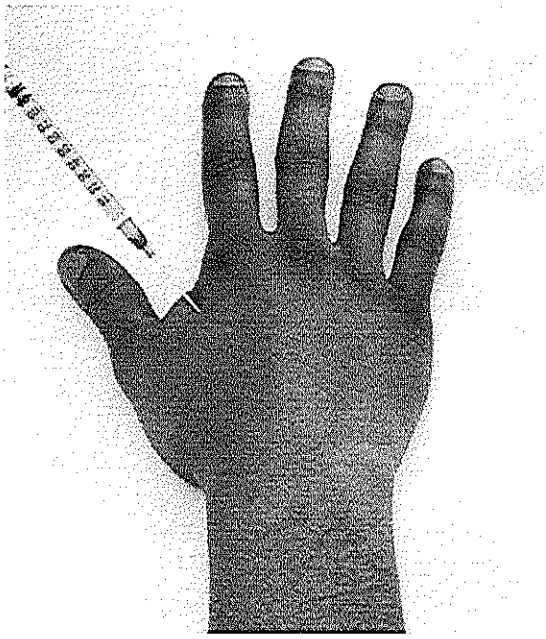

Figure A3. Black, Pain

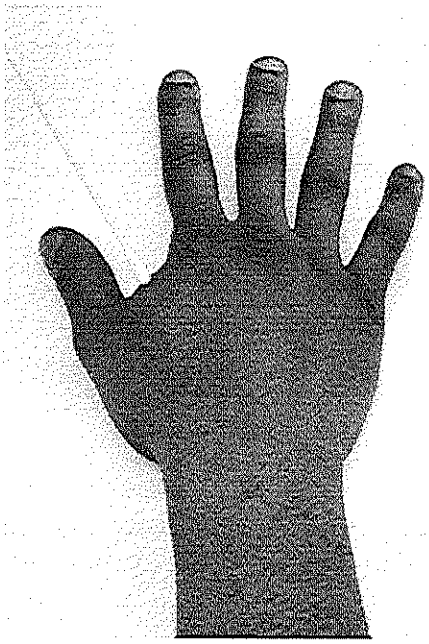

Figure A4. Black, Non-Pain